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Laboratory investigation of the effect of sea foam on the scattering of microwave radiation

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This paper models the impact of the presence of foam on the short-wave component of surface waves and momentum exchange in the atmospheric boundary layer at high winds. First, physical experiments were carried out in a wind-wave flume in which foam can be artificially produced at the water surface. Tests were conducted under high wind-speed conditions where equivalent 10-m wind speed, U10, ranged 12–38 m/s, with measurements made of the airflow parameters, the frequency-wavenumber spectra of the surface waves, the foam coverage of the water surface, and the distribution of the foam bubbles.

Microwave measurements were performed using a coherent Doppler X-band scatterometer with a wavelength of 3.2 cm and a sequential reception of linearly polarized radiation. It was shown that the presence of foam reduces the NRCS of the agitated water surface. Foam formations are concentrated mainly on the ridges and front slopes of wind waves, which make the main contribution to the scattering of radio waves. This may explain the effect of reducing the total NRCS: foam, which has less reflective properties, masks the main diffusers on the water surface. The second mechanism is associated with the effect of foam on short waves, by analogy with surfactant films.

The effect of foam on the shape of the Doppler spectrum of a microwave signal scattered by the water surface was investigated. In the case of weak wind, the presence of foam on the surface leads to a decrease in the short-wave part of the spectrum of surface waves and, as a result, to a decrease in the scattered signal. In addition, a mirror component appears in the Doppler spectrum corresponding to the fundamental frequency of the wave. In the case of a stronger wind, the grouping of additional scatterers (foam) on the crests of the waves leads to a shift of the Doppler spectra to the high-frequency region.

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